

# BANGLADESH TIGER ACTION PLAN

## 2009-2017



**BANGLADESH FOREST  
DEPARTMENT**



**MINISTRY OF ENVIRONMENT  
AND FORESTS**



## **BANGLADESH FOREST DEPARTMENT**

## **MINISTRY OF ENVIRONMENT AND FORESTS**

Suggested citation: Ahmad, I. U., C. J. Greenwood, A. C. D. Barlow, M. A. Islam, A. N. M. Hossain, M. M. H. Khan, J. L. D. Smith. 2009. Bangladesh Tiger Action Plan 2009-2017. Bangladesh Forest Department, Ministry of Environment and Forests, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

**Copyright © 2009 Bangladesh Forest Department**

### **AUTHORS**

Isthiaq U. Ahmad, Bangladesh Forest Department  
Christina J. Greenwood, Zoological Society of London and Wildlife Trust of Bangladesh  
Adam C. D. Barlow, Zoological Society of London and Wildlife Trust of Bangladesh  
Md. Anwarul Islam, University of Dhaka and Wildlife Trust of Bangladesh  
Abu N. M. Hossain, Bangladesh Forest Department  
M. Monirul H. Khan, Jahangirnagar University and Zoological Society of London  
James L. D. Smith, University of Minnesota

### **CREDITS**

Photo credits: Elisabeth Fahrni Mansur and Rubaiyat Mansur Mowgli (front cover, p 15, 20, 25, 40, 54), NASA (p 19), M. Monirul. H. Khan (p 34), Zahangir Alom (p 14), Samiul Mohsanin (p 41).  
Remaining photos by Adam Barlow and Christina Greenwood. All photos are copyrighted for reproduction which can be done only with the prior permission of the respective authors.  
Layout and design: Tanjilur Rahman and Christina Greenwood

# CONTENTS

## LIST OF FIGURES AND TABLES

## ABBREVIATIONS USED IN THE TEXT

## EXECUTIVE SUMMARY

### PART A: CONTEXT

1. WHY IS IT IMPORTANT TO SAVE THE TIGER?
2. TIGER DISTRIBUTION AND STATUS IN BANGLADESH
3. THE SUNDARBANS ECOSYSTEM AND ITS MANAGEMENT

### PART B: THREATS AND CHALLENGES

1. THREATS
  - 1.1. Direct tiger loss
  - 1.2. Prey depletion
  - 1.3. Habitat loss and degradation

#### 2. CHALLENGES

- 2.1. Institutional development and policy
- 2.2. Forest protection and law enforcement
  - 2.2.1. Sundarbans protection
  - 2.2.2. Legislation
- 2.3. Education and awareness
- 2.4. Research and monitoring
- 2.5. Collaboration

### PART C: ACTION PLAN

1. OVERVIEW
2. VISION AND GOALS
3. OBJECTIVES AND STRATEGIC ACTIONS
4. PRIORITISATION
5. MONITORING AND EVALUATION
6. HOW TO GET INVOLVED

## LITERATURE CITED

## LIST OF FIGURES AND TABLES

### Figures

- 1 Tiger conservation areas in Bangladesh and adjoining countries (Sanderson *et al.* 2006)
- 2 Relative abundance of tigers in the Sundarbans of Bangladesh (Barlow *et al.* 2008)
- 3 Wildlife Sanctuaries and distribution of Forest Department guard posts in the Bangladesh Sundarbans

### Boxes

- 1 Tiger-human conflict in the Sundarbans
- 2 Legislation, conventions, and national plans at a glance
- 3 Collaboration for conservation: Examples from other countries
- 4 Monitoring changes in tigers, prey, and habitat

### Tables

- 1 Threats, objectives, and strategic actions
- 2 Challenges, objectives, and strategic actions

## ABBREVIATIONS USED IN THE TEXT

ACF	Assistant Conservator of Forests
BTAP	Bangladesh Tiger Action Plan
CBD	Convention on Biological Diversity
CCF	Chief Conservator of Forests
CF	Conservator of Forests
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DFO	Divisional Forest Officer
DWNP	Department of Wildlife and National Parks Peninsular Malaysia
FD	Bangladesh Forest Department
GIS	Geographical Information System
GoB	Government of Bangladesh
GPS	Geographical Positioning System
IPAC	Integrated Protected Area Co-management Project
MoEF	Ministry of Environment and Forest
MYCAT	Malaysian Conservation Alliance for Tigers
NGO	Non-Governmental Organisation
TCL	Tiger Conservation Landscape
THC	Tiger-Human Conflict
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WNCC	Wildlife and Nature Conservation Circle

## PREFACE

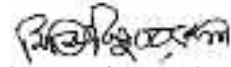
Wildlife is an integral part of a forest ecosystem. The further development of our wildlife conservation capabilities is therefore needed to deal with the threats faced by the tiger and other wildlife. To combat threats we need to improve our understanding of their root causes and how they impact tigers, so that we can focus conservation efforts for maximum effect. There is also a pressing need to address the severe tiger-human conflict in the Sundarbans, to minimize the resulting human misery and loss of tigers. In addition, given the potential of poaching to decimate tiger and prey populations, the department needs to develop dedicated wildlife staff to tackle this threat. These and other initiatives are outlined in the Bangladesh Tiger Action Plan, which is a policy-level document providing guidelines for tiger conservation efforts over the next eight years. These guidelines will be periodically revised to reflect new findings and adapt to changing conditions. Part A provides context about the current status of tigers in Bangladesh, and an overview of the Sundarbans ecosystem and its management. Part B outlines the threats to tigers, their prey, and their habitat in Bangladesh. This section also describes the challenges of building a successful tiger conservation programme capable of dealing with the threats. The action plan is outlined in Part C, which provides a vision, goals, and objectives to guide an integrated and holistic programme to address both threats and challenges to tiger conservation. To ensure involvement of those people who live around the forests are directly affected by tigers, the FD and partners plan to develop a participatory tiger conservation programme for the Sundarbans. This programme will facilitate collaboration with all stakeholders to implement tiger conservation activities and shape future conservation strategies.



Isthiaq U. Ahmad  
Conservator of Forests  
Wildlife Management and Nature Conservation Circle  
Forest Department

## FOREWORDS

The presence of the tiger has helped shape human culture, yet, despite its national and international popularity, the tiger is in trouble across its range. Most tiger populations are small and therefore more vulnerable to extinction. Bangladesh is fortunate, however, because we hold one of the largest remaining populations of wild tigers. The Sundarbans represents a last stronghold for the species. Bangladesh, therefore, has a big responsibility to secure this national treasure and ensure the continued existence of this species on earth. This Bangladesh Tiger Action Plan highlights the need for a strengthened conservation effort to achieve this aim, built through committed government efforts and partnership at all levels. As a government, we need to ensure that resources are channelled to the conservation of tigers and their remaining habitat to reflect their importance to the future of the species as a whole, and to the security of the Bangladeshi people.



Advocate Md. Mostafizar Rahman M.P.  
State Minister, Ministry of Environment and Forests

Bangladesh's future is intertwined with that of its environment, so it is essential for biodiversity conservation to be mainstreamed into development policy and action. As the national animal of our country, the tiger represents an ideal focal point for our conservation efforts, particularly for the Sundarbans. As a symbol of ecosystem health, the tiger and its conservation are integral to the future of this forest. The conservation of the Sundarbans and the coastal greenbelt is critical for the security of the nation, particularly in light of predicted impacts of climate change. The Sundarbans provides essential ecological services for the whole region and the livelihoods of millions of local people. We must protect this precious national asset at any cost. The future of the Sundarbans and the benefits it provides are reliant upon responsible use of resources as part of a holistic conservation approach. In addition to domestic intervention, Bangladesh needs to reach out to the global community to tackle the international demand and illegal trade in tiger parts which directly threaten the future of our tigers and their forest. It is against these challenges that the Bangladesh Tiger Action Plan has been developed in order to provide guidelines for tiger conservation efforts over the next eight years.



Dr. Mihir Kanti Majumder  
Secretary, Ministry of Environment and Forests

The Forest Department is committed to the conservation of the forests of Bangladesh for future generations to come. Our field staff in the Sundarbans face many hardships and dangers to protect our forest and its tigers. Our aim is to reinvigorate these field staff by making sure that they have the resources and capacity to carry out their duties and by rewarding initiative and hard toil. There is also a need for the development of wildlife management skills to face the unique challenges of tiger conservation in the Sundarbans. Indeed, the conservation of all of our forests and their wildlife will require further strengthening of skills in the field of biodiversity conservation and protected area management. One of our greatest challenges will be to find a balance between supporting human demands on the forest, whilst ensuring its continued existence. We need to reach out beyond the forest boundaries to dependent communities to find alternatives capable of reducing the pressure on the Sundarbans and its tigers.

The Bangladesh Tiger Action Plan provides us with the direction for this journey which can only be ensured by working together.



Md. Abdul Motaleb  
Chief Conservator of Forests, Forest Department

## ACKNOWLEDGEMENTS

This project was made possible by the vision of the Bangladesh Forest Department. Support was provided by the United States Fish and Wildlife Service, Zoological Society of London, Wildlife Trust of Bangladesh, and the University of Minnesota.

Earlier drafts of this document were greatly improved by the edits and insights from the following reviewers: Nasir Ahmed, Fred Bagley, Sujoy Banerjee, Shannon Barber-Meyer, Sarah Christie, Peter Cutter, Mihir Kanti Doe, John Goodrich, A.J.T. Johnsingh, Ullas Karanth, Linda Kerley, Niaz Ahmed Khan, Mohammad Ali Reza Khan, Matthew Linkie, Colby Loucks, Tom Maddox, Nalini Mohan, Sabir Bin Muzaffar, Razia Quadir, Alan Rabinowitz, S.M.A. Rashid, A.H.M. Ali Reza, George Schaller, Md. Sohrab Uddin Sarker, Rishi Sharma, Mahendra Shrestha, Neaz Ahmad Siddiqi, Paul M. Thompson, Eric Wikramanayake, and Robert Winterbottom.

During the two national review workshops, the following also gave valuable suggestions: Farid Uddin Ahmed, Md. Yunus Ali, M. Abdul Aziz, Fred Bagley, Haradan Banik, Philip Decosse, Ronald Halder, Enam Ul Haque, A.K. Fazlul Hoque, Md. Akbar Hossain, Anwar Hossain, Sirajul Hossain, Haseeb Md. Irfanullah, Md. Mozaharul Islam, Md. Shafiqul Islam, Md. Tariqul Islam, Md. Mofizul Kabir, Shirina Khatun, Md. Altaf Hossain Khan, Mihir Kanti Majumder, Md. Abdul Motaleb, Razia Quadir, M. Mahfuzur Rahman, Safiqur Rahman, Amalendra Saha, Sohrab Uddin Sarker, A.K.M. Shamsuddin, Ram Sharma, Neaz Ahmad Siddiqi, Rezaul Sikdar, and Abani Bhushan Thakur.

Special thanks also go to the Wildlife Trust of Bangladesh tiger project team who supported the authors in the creation of this plan: Md. Modinul Ahsan, M. Abdul Aziz, Suprio Chakma, Gawsia Wahidunnessa Chowdhury, Alam Howlader, Khairul Islam, Israt Jahan, Mostfa Khan, Samiul Mohsanin, Hasan Rahman, Mizan Rahman, and Mayeen Uddin.



## EXECUTIVE SUMMARY

Wild tigers are a symbol of healthy ecosystems upon which biodiversity and mankind depend. Sitting at the top of the food pyramid tigers require large areas of land to support viable populations, so act as an umbrella species for securing the future of other species that share their habitat. Furthermore, tiger forests provide a range of ecological services vital to our own existence. Tigers are also a valuable part of human culture and a focal point of many tourist visits to Asia. Equally important is the tiger's intrinsic right to survive irrespective of the needs of mankind.

With fewer than 4,000 individuals left in the wild, the tiger is severely threatened throughout its range. The mangrove forests of the Bangladesh Sundarbans support one of the largest populations of tigers in the world with an estimated 300–500 tigers, and an unknown number of tigers occur in the Chittagong Hill Tracts bordering India and Myanmar. Bangladesh, therefore, has an opportunity to contribute significantly to the conservation of tigers and to benefit from their continued presence. However, tigers are threatened in Bangladesh by direct loss, prey depletion, and habitat degradation. Tigers are directly threatened by poaching to supply the increasing demand for tiger products. In addition, Bangladesh suffers high levels of tiger–human conflict, manifested in human killing, livestock depredation, and ultimately the retribution killings of tigers by affected local communities. Poaching of prey further reduces the capacity of the forest to support tigers, and unsustainable forest use and climate change threaten to reduce the area in which tigers can live. In building a successful tiger conservation effort, there are a range of challenges that need to be dealt with relating to: (1) institutional development and policy, (2) forest protection and law enforcement, (3) education and awareness, (4) research and monitoring, and (5) the need for collaboration.

The Bangladesh Tiger Action Plan (BTAP) marks the beginning of a structured approach to achieving long-term conservation of tigers in Bangladesh. The BTAP is a policy-level document that provides a vision, goals, and objectives to guide an integrated and focused tiger conservation programme. The vision is to ensure protected tiger landscapes in Bangladesh, where wild tigers thrive at optimum carrying capacities and which continue to provide essential ecological services to mankind. The main goal for the next eight years is to stabilise or increase the Sundarbans tiger population. The Bangladesh Forest Department, under the Ministry of Environment and Forests, is the custodian of the forest and its wildlife, but one of the most important aspects of the BTAP is the recognition that the immense task of tiger conservation necessitates support and expertise outside the normal remit of forest management. Therefore, the establishment of a Forest Department-led platform that facilitates collaboration for the implementation of conservation activities will be fundamental to its success.



# PART A

# Context









A tiger lying in the *nypa* palm at the edge of a Sundarbans canal

## 1. WHY IS IT IMPORTANT TO SAVE THE TIGER?

We have a stark choice to make about what kind of relationship we have with the earth. One option is to continue down the path of short-term economic gain enabled through unsustainable resource use and environmental degradation. The other option is a long-term strategy that ensures protection of the natural systems that support life, including our own.

The fates of humans and tigers are intertwined; tigers are an integral part of much of the remaining Asian forest ecosystems, which in turn supply the ecological services essential to our own existence. Tigers are an umbrella species, because they need large areas of land to live, and so saving tigers can also help secure the future of the biodiversity that make up the tiger's forest home. As the top predator, the tiger may help to regulate the number and distribution of prey, which in turn will impact forest structure, composition and regeneration (Ale and Whelan 2008; Wegge et al. 2009). Hence the loss of tigers may reduce ecosystem integrity and ability to adapt to changing environmental conditions.

Tigers have also become ingrained in our culture and so act as a flagship species, drawing public support for conserving an entire ecosystem. Tourists travel from far and wide for a chance to

glimpse the most magnificent of all cats, and so provide valuable sources of income and employment opportunities for tiger range countries.

Irrespective of their use to mankind, as a product of millions of years of evolution, tigers should also be given the chance to exist in their own right. The disappearance of tigers from the wild as a result of human actions, would be unpardonable and a sad reflection on our role as guardians of the natural world. If we can't save the tiger, then this will surely be a signal for the demise of thousands of other species and wild places.

Tigers are categorised as endangered because there are probably fewer than 4,000 individuals left in the wild, and three of the eight subspecies are now extinct (IUCN 2008). The remaining populations continue to be imperilled by poaching, depletion of their prey, and destruction of their habitat. The most recent summary of tiger status worldwide suggests they are living in only seven percent of their former range (Dinerstein et al. 2007). The remaining tiger populations are spread across 14 countries, and often in forests too small and isolated for their long-term persistence. The way forward is to identify landscapes that can support tigers, prioritise them in terms of their contribution to the species' survival, and then protect those areas (Sanderson et al. 2006).

With a relatively large tiger population in the Sundarbans (Barlow 2009), and reports of tigers still present in the Chittagong Hill Tracts, Bangladesh has

the opportunity to contribute substantially to the future of the species. As well as the ecological services these tiger landscapes provide, the tiger is the national animal of Bangladesh, the emblem of the East Bengal Regiment which fought for the country's liberation, the logo of the national cricket team, and otherwise deeply embedded in the country's culture.

It is distressing to imagine a Bangladesh or a world without wild tigers. With careful planning and concerted effort, that prospect does not have to become a reality.

## 2. TIGER DISTRIBUTION AND STATUS IN BANGLADESH

Tigers were once widespread in Bangladesh and even up to the 1930s they were reportedly present in 11 out of 17 districts (Mitra 1957). However, widespread hunting and forest depletion has reduced the tiger's range and numbers. Now the largest remaining population of tigers is in the Sundarbans, although there are also reports of

vagrant tigers in the Chittagong Hill Tracts (Khan 1986; Khan 2004; Reza *et al.* 2004). An area of forest near Teknaf was included as a survey landscape by Sanderson *et al.* (2006), but there have not been any reports of tiger presence there in recent decades (M.M.H. Khan pers. obs.).

**Chittagong Hill Tracts:** There are reports of tigers in the mixed evergreen hill tract valleys of Kassalong-Sajek and Sangu-Matamuhuri, which are contiguous with forests in India and Myanmar respectively (Khan 2004) (Fig. 1). Both of these sites are within an area classified as a Tiger Restoration Landscape, contiguous with the Northern Forest Complex-Namdapha-Royal Manas Global Priority Tiger Conservation Landscape (TCL) (Sanderson *et al.* 2006) (Fig. 1). Because of the unknown status of tigers in the Chittagong Hill Tracts, this BTAP will not focus on this area, apart from mentioning the need for a preliminary survey.

**Sundarbans:** This area has been identified as a Class 3 TCL of Global Priority (Sanderson *et al.* 2006), and at approximately 10,000 km<sup>2</sup>, the Sundarbans of



The Sundarbans at high tide

Bangladesh and India is the largest mangrove forest in the world. This BTAP addresses tiger conservation in the 6,000 km<sup>2</sup> Bangladesh Sundarbans, referred to hereafter as 'the Sundarbans'.

Although some work has been published on Sundarbans tigers (for example, Hendrichs 1975; Seidensticker and Hai 1983; Blower 1985; Khan 1987; Tamang 1993; Reza *et al.* 2001a; Reza *et al.* 2001b; Bangladesh Forest Department 2004; Reza *et al.* 2004; Khan and Chivers 2007; Barlow *et al.* 2008; Barlow 2009), relatively little is known about their ecology and status compared to better studied populations in Nepal, India, and Russia (Smith and McDougal 1991; Carroll and Miquelle 2006; Karanth *et al.* 2006). Tigers are known to be present throughout the Sundarbans,

with higher concentrations found in the south and west compared to the north and east (Fig. 2) (Barlow *et al.* 2008).

A study using GPS collars recorded home ranges of two female tigers in the south-east of the Sundarbans. The two tigers were living in relatively good habitat with respect to other areas in the Sundarbans, but their small home ranges (< 20 km<sup>2</sup>) are still probably indicative of a very high density compared to other tiger habitats. Even if tiger home ranges are double this size in other areas of the forest, the Bangladesh side of the Sundarbans could still support 100-150 breeding females or 300-500 tigers overall (Barlow 2009).

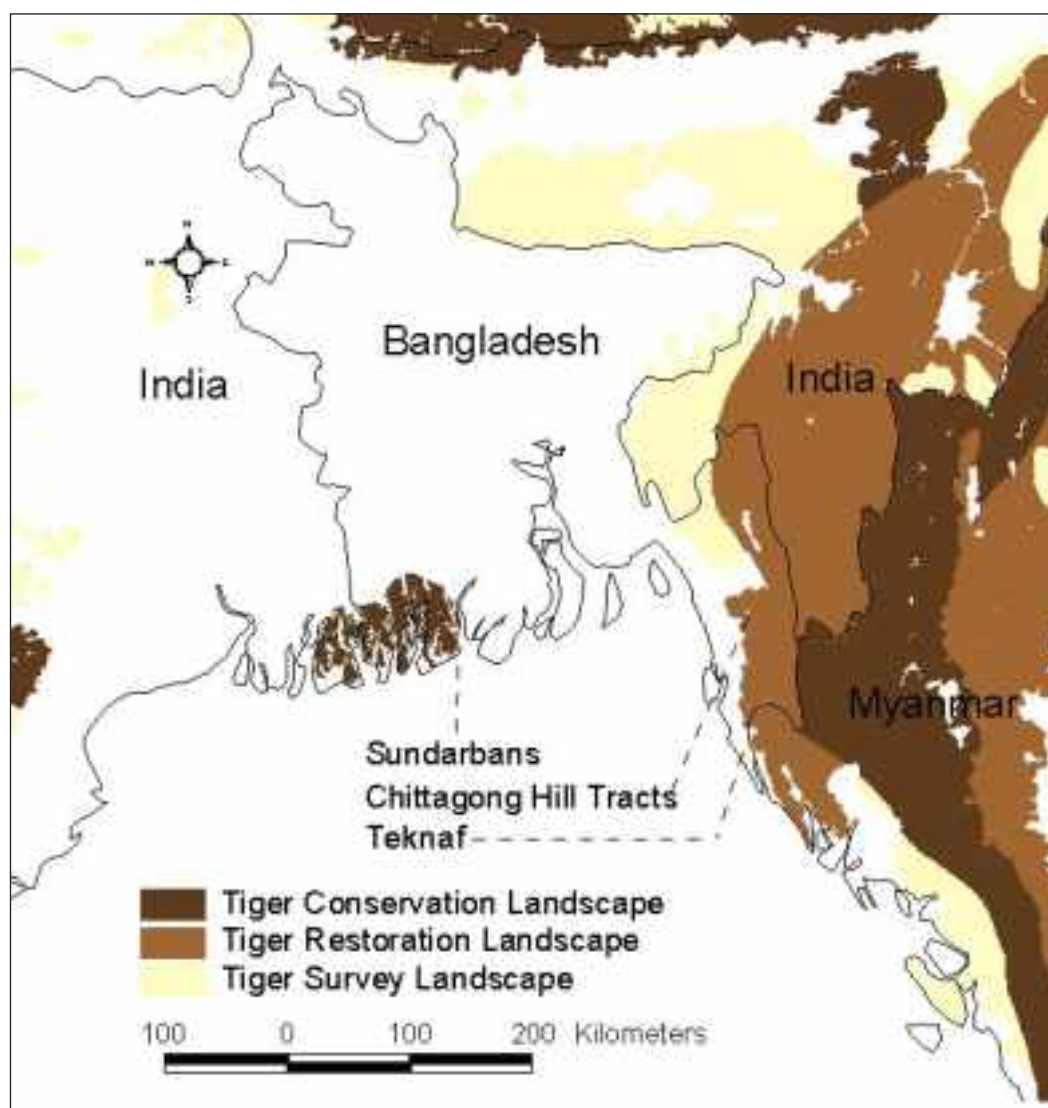


Figure 1. Tiger conservation areas in Bangladesh and adjoining countries (Sanderson *et al.* 2006)



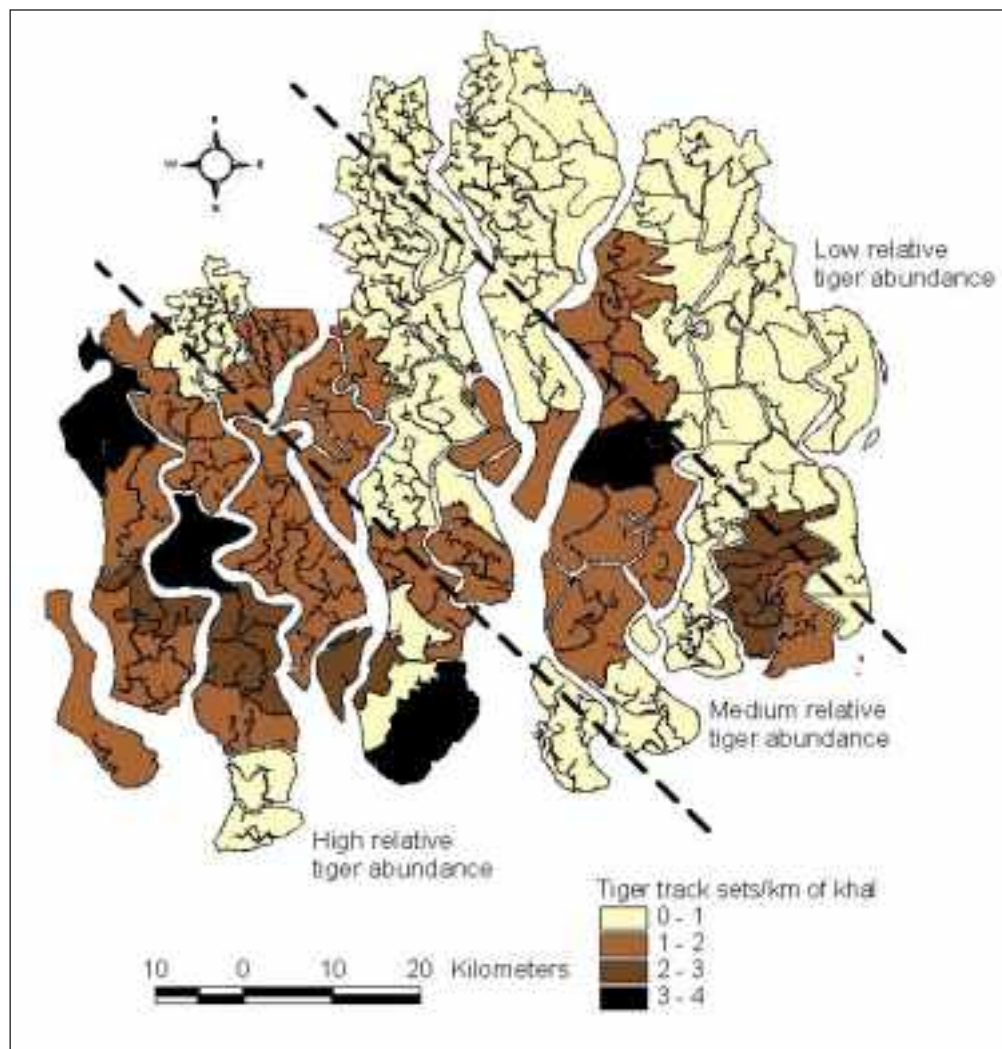


Figure 2. Relative abundance of tigers in the Sundarbans of Bangladesh (Barlow et al. 2008)



Satellite image of the Bangladesh and Indian Sundarbans

### 3. THE SUNDARBANS ECOSYSTEM AND ITS MANAGEMENT

Bangladesh lies in the vast fertile delta of three of the largest rivers in the world: the Ganges, the Brahmaputra, and the Meghna. The Sundarbans mangrove forest is found at the lower moribund end of the delta where it meets the Bay of Bengal. The Sundarbans continues to be shaped by the tonnes of sediment deposited by the rivers and ocean currents, and changes in human land use (Allison *et al.* 2003). The Sundarbans represents nearly half of the remaining forests of Bangladesh and is dominated by halophytic tree species such as *sundri* (*Heritiera fomes*), *gewa* (*Excoecaria agallocha*), *goran* (*Ceriops decandra*), *baen* (*Avicennia officinalis*), and *keora* (*Sonneratia apetala*). It is inhabited by some 49 mammal, 59 reptile, eight amphibian, 315 bird, and 200 to 300 fish species (Chaudhuri *et al.* 1994; Hussain and Acharya 1994; Khan 2004).

As well as protecting a unique array of biodiversity, saving the Sundarbans will also secure essential ecological services such as (1) trapping of sediment and land formation, (2) protection of human lives and habitation from regular cyclones, (3) its role as a nursery for fish and other aquatic life, (4) oxygen production, (5) waste recycling, (6) timber

production, (7) supply of food and building materials, and (8) carbon cycling (Biswas *et al.* 2007; Islam and Peterson 2008). Such services are of global and national importance, and fundamental to the livelihoods of the local people living along the Sundarbans border; several million people directly depend upon the collection of timber,

fuelwood, fibres, fish, shells, wax, honey, and other non-timber forest products. This resource extraction feeds both local needs and industry, with the forest producing almost half of the total timber and fuelwood for Bangladesh (Canonizado and Hossain 1998).

Each year as many as 100,000 Bangladeshi tourists make day trips to Karamjal, a tourist spot in the northern part of the Sundarbans (Md. Abdur Rob, Forest Department, pers. comm.). Here they can take short walks in the forest and view captive animals such as spotted deer (*Axis axis*), rhesus macaque monkeys (*Macaca mulatta*), and estuarine crocodiles (*Crocodylus porosus*). A handful of tour operators also run trips lasting three to four nights that go deeper into the forest to visit key sites, mainly inside the Sundarbans East Wildlife Sanctuary.

Regulation of resource extraction, tourism, revenue collection, and law enforcement is carried out by the FD, under the Ministry of Environment and



A basking estuarine crocodile



Forests. For management purposes, the forest and its waterways have been delineated into four ranges and 55 compartments, guarded by over 90 FD posts (Fig. 3). The Sundarbans is classified as a Reserved Forest, in which some forms of resource extraction are allowed, but it is illegal for anyone to live, cultivate land, or graze livestock in the forest. To ensure additional protection for wildlife habitat and natural resources, three areas within the forest have been designated as Wildlife

Sanctuaries: Sundarbans West (715 km<sup>2</sup>), Sundarbans South (370 km<sup>2</sup>), and Sundarbans East (312 km<sup>2</sup>). These Wildlife Sanctuaries are closed to any extraction of vegetation or wildlife and have been collectively declared a UNESCO World Heritage Site (Fig. 3) (Iftekhar and Islam 2004). The border between the Bangladesh and Indian sides of the forest is patrolled by Bangladeshi Rifles servicemen, and the Navy and Coast Guard patrol coastal waters.

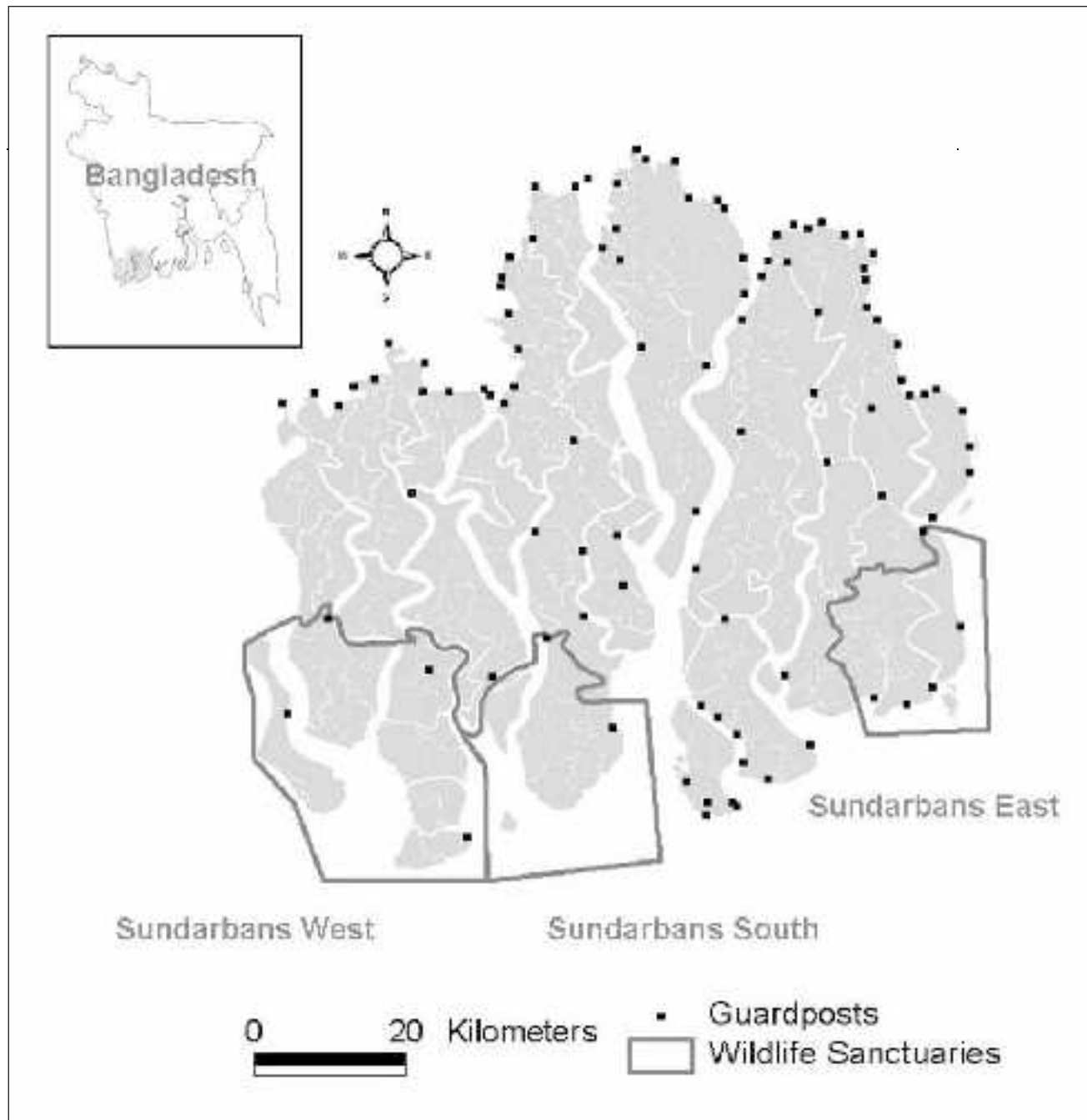


Figure 3. Wildlife sanctuaries and distribution of Forest Department guard posts in the Bangladesh Sundarbans

# PART B

## Threats and Challenges



## 1. THREATS

Like all living beings, tigers need food and space to survive. However, tigers, their prey, and their habitat are all threatened in Bangladesh. This section outlines current understanding about the nature, scale, and cause of these threats. There is a dearth of information across all threats, however, so it is inevitable that some are poorly defined and others have yet to be identified. In addition, the inferences regarding causality may be weak because often they are not based on empirical research. Further research and subsequent monitoring of threats are urgently needed.

### 1.1. Direct tiger loss

Tiger poaching and associated trade have potential to decimate a population over a short period of time (Kenny *et al.* 1995). Little is known about tiger poaching in Bangladesh, with cases only being documented from opportunistic arrests or seizures by the authorities. At present, low numbers of poaching incidents are reported from the Sundarbans, with up to two incidents each year (FD records), but the majority of incidents are unlikely to be detected due to the covert and illegal nature of this activity. There is also little known about the national demand for tiger parts, although a 1997 survey reported substantial trade in tiger skins, teeth, and claws (Nowell 2000). However, there is a high regional demand for tiger products and an established international trade (Nowell 2000; Nowell and Xu 2007), so it is unlikely that Bangladesh will be overlooked as a source of tiger parts, particularly as other tiger populations dwindle. The geographical position of Bangladesh between India and Myanmar, countries that experience rampant poaching, may further increase the vulnerability of the Sundarbans tigers (Nowell and Xu 2007).

Some tigers are also killed through retribution killings associated with tiger-human conflict (THC). FD records show that up to three tigers are killed each year (Reza *et al.* 2002a; Barlow 2009). These retribution killings are a result of bad feelings towards tigers due to human - or livestock - killing incidents or simply because the tiger is perceived as a threat when it strays into a village (FD Records; Barlow 2009). THC creates negative attitudes in local communities towards tigers, making achievement of long-term conservation objectives difficult (Box 1).

There is always the potential for tigers to die from disease, but there has been no research in this area. Furthermore, it is likely that tigers that die from disease will do so undetected unless the population is subject to intensive study. Captive tigers have died from Avian Influenza, and captive and wild tigers have died from Canine Distemper (Appel and Summers 1995; Myers *et al.* 1997; Keawcharoen *et al.* 2004; Goodrich *et al.* 2005). Feline Immunodeficiency Virus is also widespread amongst wild felids and has been found present in tigers (Olmsted *et al.* 1992). Other potential tiger diseases include Feline Chlamydophila, Dirofilaria, Feline Calicivirus, Feline Coronavirus, Feline Leukaemia Virus, Feline Herpes Virus, Feline Parvovirus, Tuberculosis, Pseudo-rabies, Rabies, and Sarcoptic Mange (John Lewis, Doctor of Veterinary Medicine, Wildlife Vets International pers. comm.). Another potential threat to the isolated Sundarbans population is inbreeding depression, but this may not be a high priority issue considering the relatively large size of the population.

### 1.2. Prey depletion

The number of tigers that an area can support is largely dependent upon the number of suitable prey (Smith *et al.* 1987; Karanth *et al.* 2004). The main prey for tigers in the Sundarbans is spotted deer (*Axis axis*) and to a lesser extent wild boar (*Sus scrofa*) (Reza *et al.* 2001a, 2001b, 2002b; Khan 2004). Barking deer (*Muntiacus muntjak*) are also present in low numbers, and may fall prey to tiger (Khan 2004). Earlier studies reported a more diverse range of prey species, including swamp deer (*Cervus duvauceli*), hog deer (*Axis porcinus*), and wild water buffalo (*Bubalus bubalis*), but these are no longer present (Curtis 1933; Seidensticker and Hai 1983; Blower 1985).



Prey depletion is a serious threat to any tiger population and there are signs that it is occurring in

### Box 1. Tiger-human conflict in the Sundarbans

Finding solutions to minimise THC conflict is essential to reduce the misery inflicted on local communities and secure their support for tiger conservation. The Bangladesh Sundarbans suffers the highest level of human-killing by tigers in the world (Barlow 2009), and recent surveys suggest that livestock-killing and retaliatory killings of tigers are also acute problems (Rahman Unpubl. data). In addition to personal bereavement, the loss of a working family members or livestock is a significant economic loss to an already impoverished household. Conserving tigers in the Sundarbans, therefore, also includes a moral obligation to help the people that suffer because of the tiger's presence.

**Human-killing** usually affects people entering the forest to harvest resources, and is mainly concentrated in the west (Reza *et al.* 2002a; Barlow 2009). An average of 20 to 30 people are killed each year according to FD records (1984-2006), although up to 96 cases in a year have been documented in earlier periods (Curtis 1933; Hendrichs 1975). The total number of cases is probably higher than reported, however, because (1) some people who are injured but later succumb to their wounds are not recorded, and (2) some non-permit holders killed might not be reported to the FD (Jagrata Juba Shangha 2003).

**Retaliatory killing of tigers** is known to account for up to three tiger deaths a year. If tigers are found in villages or neighbouring fields, they are often killed by the villagers who surround the tiger and beat it to death with sticks. Poisoning, shooting, or snaring may also be used in retribution killings, but the extent or effect of these practices is unknown. This additional source of tiger loss could have a sizeable impact on the long-term viability of the tiger population (Chapron *et al.* 2008; Goodrich *et al.* 2008).



**Livestock depredation** occurs in many villages along the forest boundary, particularly in the east. Results from preliminary surveys suggesting that about 80 livestock are killed every year (Khan Unpubl. data; Rahman Unpubl. data), but the causes and potential solutions for livestock depredation have yet to be identified.

**First steps to reduce the conflict** are being piloted by the FD and partners in the form of Tiger Response Teams. A boatbased team tackles human-killing inside the forest by providing medical assistance, transporting victims, retrieving bodies, and patrolling areas where human-killers are active. Village-based response teams are being created in the bordering village areas to deal with stray tigers and monitor livestock-killing. The teams are reached through a Tiger Hotline number publicised in FD posts and villages (Greenwood 2009).

**Tiger Response Team boat unit patrolling in the west**



the Sundarbans, with snaring apparently the most common practice (Jagrata Juba Shanga 2003). This technique can also kill non-target species such as tigers. Preliminary investigations suggest that many forest users poach deer as a secondary activity to support their own food requirements while working in the forest, and to supply friends and family when they return to their communities (Mohsanin Unpubl. data). The nature and scale of specialist poaching efforts are unknown, but the market for wild meat consumption is thought to be largely local (Khan 2004).

Prey could also be depleted through disease introduced by domestic animals; in some northern parts of the forest, deer share habitat with cows and goats which graze illegally inside the forest (Rahman Unpubl. data). No research has been carried out to understand disease occurrence in the prey population.

### 1.3. Habitat loss and degradation

Habitat loss and degradation imperil tigers by reducing, thinning, and fragmenting the area in which they can live and reproduce. The Sundarbans shares many threats to habitat in common with other tiger habitats, but also has a variety of factors unique to the socio-political landscape in which it is embedded and the particular dynamics of a mangrove ecosystem (Seidensticker and Hai 1983).

The Sundarbans is approximately half the size it was 200 years ago due to conversion to agricultural

land and shrimp farms (Curtis 1933; Biswas *et al.* 2008). However, despite being situated in the most densely populated country in the world, the current boundaries of the forest have been maintained since the early 1900s (Curtis 1933; Iftekhar and Islam 2004; Biswas *et al.* 2008). Studies suggest that coverage and density of larger diameter trees, canopy closure, and diversity have declined over the last 100 years or so (Canonizado and Hossain 1998; Iftekhar and Islam 2004; Iftekhar and Saenger 2007). However, the amount and rate of change is unclear as the studies have been based on past forest inventories which used a variety of methodologies, making comparisons to assess long term change over time problematic (Iftekhar and Saenger 2007).

### A wood cutter with loaded boat

There are a number of potential threats to the Sundarbans, perhaps the most immediate of which is the unsustainable harvesting of timber and non-timber forest products (NTFP). The burgeoning population along the Sundarbans periphery have few alternative livelihood options and therefore little choice but to depend upon the forest for their survival; thousands of people enter the forest on a daily basis to harvest timber, fuel wood, fibres, and other non-timber forest products. The most economically valuable wood species is *sundry*, a hardwood generally used for building houses, making boats, anchor posts, and fuelwood (Canonizado and Hossein 1998). The legal harvest of *sundri* has been suspended since 1990 due to



declining stock, but some illegal felling continues (Canonizado and Hossein 1998). *Gewa* is the second most valuable timber species. It was cut for paper production in government owned newspaper mills until their closure in the early 2000s when they became a losing concern. *Gewa* continues to be used for building materials, out rigging for boats, fishing materials, and fuelwood (Canonizado and Hossein 1998). *Goran* trees are cut extensively for fuelwood, used by local communities and industries such as brick manufacturing.

*Goran* bark is rich in tannins which are used to preserve fishing nets and sails. Other timber species are *keora*, *kankra* (*Bruguiera* spp.), *baen*, *dhundal* (*Xylocarpus granatum*), *passur* (*Xylocarpus mekongensis*), and *singra* (*Cynometra ramiflora*), which are used as substitutes for *sundri* and *gewa*. *Nypa* palm (*Nypa fructicans*) and Sungrass (*Imperata* sp.) are also collected for thatching materials (Canonizado and Hossein 1998). Honey and wax

are collected by specialist teams of honey hunters hired by businessmen who then sell the products on the national market. Fishermen also enter the mangroves to gather fish, crabs, and other marine life. The FD licenses fishing and maintains records of this activity, but there is no scientific monitoring or management of fish stocks (Canonizado and Hossein 1998). The impact of current extraction levels on the overall ecosystem has not been quantified, but short term studies undertaken in the 1980s and 1990s suggest this may be the main cause of the mangrove's continued degradation (Iftekhar and Islam 2004). The Integrated Forest Management Plan for the Sundarbans Reserved Forest compared the inventories carried out in 1959, 1983, and 1996 (Canonizado and Hossein 1998). The report highlighted a rapid decline in *sundri* and *gewa* growing stock, and prescribed immediate regulatory measures and a strict 20 year felling schedule (1998-2018) to ensure sustainable extraction. However, the lack of resources for forest



A young fisherman with his equipment





*Nypa* collectors at work along canal banks

protection together with demand from expanding communities and industry undermine regulation of harvesting levels. Sustainable resource extraction will, therefore, only be realised through improved forest protection, alternative livelihoods, and alternative sources of essential forest products.

There is no human habitation permitted inside the forest other than FD, coast guard, and navy camps. Infrastructure within the forest is generally limited to the buildings of these camps and some tourist facilities such as walkways and watch towers. However, there are some semi-permanent fishing communities operating at the southern edge of the forest. These fishermen use forest materials for fuelwood and in the constructions of their jetties, shelters, and fish drying beds (Canonizado and Hossein 1998). The impact of these encampments on the forest, tigers, and prey has not yet been quantified. Some forest areas close to the villages in the north and north east appear to be degraded from local wood collection, and there is also illegal grazing of domestic livestock which could reduce the available food for prey (Rahman Unpubl. data).

Other threats are more difficult to quantify or even identify because (1) their effects are less visible and might only be measurable over the long-term, and (2) they may originate outside the forest. For example, there is little information about the presence of disease and its potential impact on the forest. There are some studies on a condition known as "Top Dying" in *sundri* trees, but its impact and causes are not clearly understood (Canonizado and Hossein 1998; Iftekhar and Islam 2004). The type and distribution of invasive species has been investigated; 23 invasive plants were identified and the rate of invasion was notably higher near river banks and some areas close to human habitation (Biswas *et al.* 2007). The 2007 study concluded that, whilst control of invasive species is only successful if undertaken before the plants become well-established, invasive species in the Sundarbans were still at a manageable level. However, monitoring and management intervention activities are not in place, and the impact on tiger and prey habitat is not fully understood.

Pollution of the rivers from industrial, shipping, tourism, urban, agricultural, and aquaculture sources may be damaging the Sundarbans. However, except





**Fish drying stands in the south of the Sundarbans**

for preliminary identification of some toxins, little work has been published on the extent and impact of pollution (Hussain and Acharya 1994). Large-scale mineral and gas exploration and extraction has not been carried out so far in the Sundarbans, and its potential impact on the ecosystem, in terms of pollution and habitat destruction, has not been estimated.

Sea-level rise caused by climate change has been noted as a serious threat to habitat in the Sundarbans, with current predictions suggesting substantial land loss from increased inundation over the next 50 years (Agrawala *et al.* 2003). These predictions do not take into account the changes in compensatory factors such as sedimentation rate and mangrove adaptation (Stanley and Hait 2000; Allison *et al.* 2003); the coastal areas of Bangladesh are currently growing by about 20 km<sup>2</sup> a year (Inman 2009), and mangroves in other areas are known to have flourished despite sea-level rises of at least 3.8 mm a year (Hendry and Digerfeldt 1989). Although improved understanding of this issue is required, some current estimates of sea-level rise are over 1 m by 2100 (Hansen 2007; Rahmstorf 2007; Pfeffer *et al.* 2008), so it is prudent to develop mitigation solutions before it is too late (MoEF 2008). Tropical cyclones are a regular occurrence in the region with approximately one cyclone per year hitting Bangladesh (Islam and Peterson 2008). Climate change is expected to increase cyclone frequency, which may be an additional source of stress to the forest. The MoEF has developed a 10 year Bangladesh Climate Change Strategy and Action Plan that outlines programmes to tackle the predicted effects of climate change, including expansion of the coastal greenbelt through mangrove afforestation (MoEF 2008).

Freshwater flow into the Sundarbans may also be affected by climate change-induced alterations in rainfall and melting of Himalayan snows (Agrawala 2003; MoEF 2008). Dry season freshwater flows have

fallen due to extraction of water from the upper reaches of the Ganges for irrigation, navigation, and industry. The building of the Farakka barrage in 1975, for example, has been directly linked to the reduction of freshwater flow into Bangladesh and the Sundarbans (Iftekhar and Islam 2004). Embankments and diversion of water for irrigation within Bangladesh also reduce freshwater flows. The combined impact of increased inundation from the sea and decreased freshwater flow may increase salinity levels, particularly in the dry season, which could change vegetation patterns (Agrawala 2003), and thus effect the distribution of tigers and prey.



**A young girl bringing in her fishing net**

## 2. CHALLENGES

There remains considerable scope to expand the list and understanding of threats. However, due to the risk of losing more tigers during the lengthy time needed to collect more information, conservation activities need to be implemented now. The development of an effective tiger conservation effort is a huge challenge; a complex and urgent task requiring a holistic approach that can be swiftly adapted to changing conditions and the emergence of new information. Carrying out such an approach will require a huge increase in capacity to develop and carry out conservation activities. Capacity requirements can be grouped into five areas: institutional development and policy, forest protection and law enforcement, education and awareness, research and monitoring, and collaboration. This section outlines the current state of each area with suggestions for improvements.

### 2.1. Institutional development and policy

The FD is the custodian of wildlife and forests for the entire country, and in recent years is strengthening its commitment to biodiversity conservation. The FD was formed in 1864 during the colonial period and is responsible for the management of the Sundarbans and all other forests in Bangladesh. It has a number of territorial divisions that are responsible for the prevention of illegal activities, regulation of legal extraction, permit issuance, and revenue collection. A FD Wildlife and Nature Conservation Circle (WNCC) was formed in 2001, which established dedicated posts to safeguard wildlife, primarily in protected areas (Mitchell *et al.* 2004). The WNCC does not yet have sufficient institutional presence or resources to fully carry out its intended role. In the Sundarbans the territorial DFOs, rather than WNCC staff, currently administer both the reserved forest and the wildlife sanctuary areas. Furthermore, staff are regularly transferred between wildlife and territorial posts and also between forests, hampering the development of wildlife or ecosystem conservation specialists. Indeed, the majority of FD staff have forestry-related backgrounds so additional biodiversity conservation skills across all staff could be developed.

Retaining staff within the WNCC would enable those personnel with an interest in wildlife and conservation to receive specialised training. In addition to protected area management, responsibilities of the WNCC should extend to wildlife monitoring, wildlife crime investigation, and human-wildlife conflict mitigation. A large amount of wildlife is found outside the protected areas and WNCC staff would therefore need appropriate resources and jurisdiction. For example, high densities of tigers, THC conflict incidents, and wildlife crime are found outside the three Sundarbans wildlife sanctuaries. Specialists could

also be retained in specific forests, for example, tiger and mangrove specialists in the Sundarbans. Retention of staff within a particular forest would also allow for improved relationships with local communities to be developed over the longer term.

Generalist biodiversity conservation and protected area management training can also be provided to the territorial divisions to build on their production forestry skills. A staff review process that measures performance based on wildlife abundance and habitat condition would strengthen the impact of these organisational changes and foster a professional approach to conservation and forest management. Furthermore, conservation of the Sundarbans requires development of fisheries and wetlands management skills.

As an initial step and to progress BTAP implementation, WNCC staff could be assigned to coordinate BTAP activities. Duties would include the development of a BTAP implementation plan; design of a monitoring and evaluation approach; liaison with decision-makers in the FD, MoEF, and other ministries; and the creation of a platform to facilitate



**File keeping at Burigoalini FD office in the west of the Sundarbans**

collaboration. Selected Sundarbans FD staff can be trained to deal with THC incidents, wildlife crime investigation, and tiger, prey, and habitat monitoring activities. Associated incentives are needed that provide benefits for working on BTAP activities, such as the opportunity to undertake specialist training and further study.

Whilst the importance of the Sundarbans and its tigers is recognised, their conservation needs to be integrated into the GoB's development agenda to ensure complimentary policy and action. An economic assessment of the Sundarbans ecosystem services, together with identification of conservation-friendly revenue generation schemes, would help to mainstream Sundarbans and tiger conservation into development policy and action. Raising cross-ministry and national awareness of the importance of the Sundarbans and its tigers is needed to further garner the political support for development and integration of Sundarbans tiger-friendly policy.

## 2.2. Forest protection and law enforcement

### 2.2.1. Sundarbans protection

In addition to the development of institutional biodiversity conservation capacity, an effective FD patrolling force is essential for the prevention of illegal and damaging activities such as poaching or unsustainable wood harvesting. There is an urgent need to improve human resources, infrastructure, and patrolling efforts.

Prior to a full evaluation, field observations suggest that FD resources are insufficient for carrying out effective patrolling. Some guard posts do not have boats, and many that do have slow wooden vessels and inadequate budget for maintenance or fuel. Accommodation conditions are basic and medical facilities are extremely limited. There are normally two or more guns assigned to each guard post, but some of these weapons and associated ammunition are obsolete or non-functional.

In any case, staff rarely use their arms as existing laws do not provide them enough protection if someone is killed or injured. There are also problems with drinking water and food supplies for some forest posts.

In addition, there is no risk allowance to compensate for the unique dangers faced by FD staff in the Sundarbans. Two FD staff were killed by tigers in 2005 and one staff member was killed by a cyclone in 2007. In 2009, two more FD staff were killed in confrontations with *dacoits* (local term for robbers and pirates). There is also no budget set aside to cope with emergency situations such as periodic cyclones. Cyclone Sidr struck in November 2007 and destroyed many guard posts in the eastern side of the Sundarbans. More than a year later, little repair work has been done, several guard posts are still deserted, and others have no boats or regular source of drinking water. A disaster recovery process is needed to ensure that patrolling levels are returned to normal as quickly as possible after these devastating storms.





**A forest guard on evening patrol along a Sundarbans beach, where the southern edge of the forest meets the Bay of Bengal**

**2.2.2. Legislation**

Prior to 1973, tiger hunting in Bangladesh was legal, and bounties were offered as an incentive. The Bangladesh Wildlife (Preservation) (Amendment) Act 1974 defines the tiger and the spotted deer as 'protected animals'; they cannot be killed or captured, except for cases of self defence, protection of crops and livestock, approved scientific research, or sanctioned transport or possession. In addition, where a tiger becomes a threat to human life, the animal can be officially notified by the Chief Conservator of Forests (CCF) for capturing or killing. The Act does not apply to any wildlife products in transit through Bangladesh as long as the products are accompanied by a transit customs document. This provision may be taken advantage of, because it is difficult for customs officials to confirm the source of wildlife products and authenticity of transit documentation.

Under the 1974 Act, a set of penalties was defined regardless of the wildlife concerned: imprisonment for six months to two years and/or a fine of Taka 500-2,000 (in 2009 equivalent to only US\$7-28). The Act also provides an option wherein a FD officer, upon seizure of a wildlife product, can request compensation for the product up to Taka 50,000 and confiscate any guns and licence held by the offender; a process that waives any further prosecution. At the time of writing, the market rate for spotted deer meat was Taka 200-

500 per kilogram, so a poacher can earn Taka 20,000 or more for an adult male deer. Also, considering that tiger skins can be sold for around Taka 70,000 (Mohsanin Unpubl. data), the current economic incentives to poach far outweigh the deterrents. At the time of writing, the 1974 Act was under revision which provides opportunity for a review of penalties. Three areas in the Sundarbans were declared as Wildlife Sanctuaries under this Act, the first in 1960 and the second and third in 1996. In these areas the Act prohibits the entry of people, cultivation of land, damage or destruction of vegetation, hunting or capturing wild animals, introduction of exotic species, straying of domestic animals, causing of fires, and water pollution. These Wildlife Sanctuaries were also declared a UNESCO World Heritage Site in 1997. A number of other national and international legislative initiatives have been established to offer some level of protection to the tiger, its habitat, and prey (Box 2).

An assessment is required to investigate legislative gaps, the sufficiency of existing penalties, the perceived risk of being punished, and barriers to prosecution. The establishment of a specialist Wildlife Crime Unit would strengthen enforcement by creating improved capacity to investigate domestic crime and illegal international trade. A review can also be undertaken to ensure Sundarbans management strategies adhere to international conventions and protocols. A revision of forest zonation may also be needed to account for the current distribution of tigers and human use patterns across the landscape.



**Spotted deer grazing under a stand of *keora* trees**

## Box 2. Legislation, conventions, and national plans at a glance

### National legislation

- Forest Act, 1927 (Amended in 2000): This Act makes provision for reserved forests; it prohibits the carrying of guns, grazing of cattle, felling of any tree, removal of any forest produce, and setting fire to and clearing of land for cultivation or any other purpose.
- Bangladesh Wildlife Order, 1973, and Bangladesh Wildlife (Preservation) (Amendment) Act, 1974: The tiger and the spotted deer are defined as 'protected animals' in Schedule 3 of the Order 1973. The Order was refined and enacted as Wildlife (Preservation) (Amendment) Act 1974. The three Sundarbans wildlife sanctuaries were set up under this Act.
- The Bangladesh Environment Conservation Act, 1995: This deals with cases of environmental degradation. In 1999 under the 1995 Act, Bangladesh declared the 10 km of land adjoining the Sundarbans as an Ecologically Critical Area (ECA). The ECA rules prohibit a number of activities from damaging natural trees, animals, and fish, to establishing factories that pollute soil, water, and air. However, this area was already converted to agriculture and aquaculture, and heavily populated before the ECA was declared.

### International conventions

- CITES: The trade of tiger parts is prohibited under Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Bangladesh acceded to CITES in 1982.
- Convention on Biological Diversity (CBD): Signed by Bangladesh in 1992, the objective of this treaty is the conservation of biodiversity which is identified as being essential to socioeconomic development. This BTAP will contribute to meeting such obligation through its aim to secure the future of the Sundarbans and its tigers.
- Ramsar Convention: The Sundarbans has been designated as a Wetland of International Importance under this convention, which Bangladesh ratified in 1992. The Ramsar Convention provides a framework for the conservation and wise use of wetland resources.
- UNESCO: The three Sundarbans wildlife sanctuaries were declared a UNESCO World Heritage Site in 1997, drawing national and international attention to this unique ecosystem.
- Kyoto Protocol: In 2001 Bangladesh ratified this protocol which aims to reduce greenhouse gases contributing to climate change. The Sundarbans represents an important carbon sequestration site for the country.

### Related national strategies and plans

- Integrated Forest Management Plan for the Sundarbans Reserved Forest 1998: This plan provides a comprehensive report on current forest stocks and defines sustainable extraction levels for the next 20 years.
- National Biodiversity Strategy and Action Plan: A draft is under development (IUCN 2004).
- Bangladesh Capacity Development Action Plan for Sustainable Environmental Governance, 2007: This document identifies obligations under conventions including the CBD and Kyoto, and outlines a national plan for capacity development for biodiversity conservation and climate change adaptation (MoEF 2007).
- Bangladesh Climate Change Strategy and Action Plan, 2008: This plan was developed by the Department of Environment, MoEF. Under this plan, activities directly relevant to the BTAP include expansion of the coastal greenbelt through mangrove afforestation, development of monitoring systems to evaluate changes in ecosystem and biodiversity in all important and sensitive ecosystems, and climate change scenario modelling.

### 2.3. Education and awareness

Without political support, the BTAP and biodiversity conservation will continue to remain low on the government's agenda and separate from economic development plans and poverty reduction agendas. Support is also needed across a wide range of parties, from industry and private companies, to public organisations and local communities. Without it, the FD will not be supplied with the resources or legislative tools necessary to protect the forest, partners will not step forward to join in the tiger conservation challenge, and there will be little motivation to conserve and use natural resources sustainably.

Strategic use of education and awareness raising can support changes in knowledge, attitudes, and behaviour to help achieve conservation objectives. A tiger conservation education and awareness strategy is needed to guide the development of carefully targeted and measurable campaigns that are integrated with other BTAP programmes. Successful campaigns need to be creative in their messages and use targeted methods to engage different audiences (Hesselink *et al.* 2007). Training is needed to develop conservation communication and social marketing specialists in Bangladesh, who will then be able to design, implement, and evaluate campaigns.

In many cases, however, education and awareness alone may not be enough to change behaviours and must be used in conjunction with other conservation strategies. For example, forest users of the Sundarbans may know that they are using the forest unsustainably, but their immediate needs make it a matter of survival, in which case, education and awareness could be used to support other initiatives such as the development of alternative livelihoods.

### 2.4. Research and monitoring

Information is vital for policy formulation, development of field-level strategies, and monitoring tiger, prey, and habitat levels as indicators of overall success. Without basic understanding of a species or the ecosystem in which it lives, it is not possible to assess the impact of various threats or predict and evaluate the outcome of management activities. Equally, without understanding the socio-economic context, which is often the underlying cause of many of the threats, little headway will be made in the development of long-lasting solutions. This information is lacking for most tiger landscapes, and the Sundarbans is no exception (Sanderson *et al.* 2006).



Tiger conservation discussions in a local village



The information that could be obtained on Sundarbans tigers and the threats they face is infinite, but only some has potential to guide conservation actions. A prioritised national BTAP research and monitoring agenda would help direct research activities in line with management needs. It is unrealistic for the FD to collect all of the required information, so independent researchers should be engaged. It is also good practice to involve independent researchers in monitoring activities to ensure transparency in interpretation of results. However, currently there are few ecological and social studies being carried out that can directly inform conservation strategies and only a small number of people involved in tiger conservation research.

Public universities generally do not have enough funds to give national students the opportunity to undertake often costly Sundarbans fieldwork. Scholarships would increase the number of students able to undertake Sundarbans research and build a new generation of tiger conservationists for the country. Field stations could also be established close to the Sundarbans by universities and NGOs to facilitate research activities. A centre for tiger and Sundarbans conservation research would make research findings freely available and provide access



**Radio-tracking tigers in the Sundarbans**

to the latest approaches and techniques from around the world. This would encourage collaborative efforts and innovative research. There is also a need to improve the availability of national conservation biology undergraduate and graduate training, and the involvement of students and professionals with social science backgrounds.

## **2.5. Collaboration**

The immense scale and multifaceted nature of tiger conservation requires a wide array of skills and resources. Collaboration with other government departments, local communities, academic institutions, national and international NGOs, and the private sector is needed to develop a successful tiger conservation effort.

There are a number of organisations already involved in different aspects of biological research, socio-economic studies, GIS projects, and biodiversity



**Honey collectors – vulnerable to tiger attacks as they search the forest for honey combs**

conservation activities across the country. A platform is needed to engage these and other organisations and coordinate an integrated tiger conservation programme. An FD-led alliance could facilitate this, following examples from other countries (Box 3). This



would also provide a platform for the FD and collaborators to support one another in securing funding to carry out BTAP activities.

It is also essential to engage with the people who directly rely upon the Sundarbans resources for their economic wellbeing and those whose lives are directly affected by tiger-human conflict. Integration of these communities into forest management will shift the overall paradigm from top-down policing to a more inclusive and mutually beneficial approach. This would build on previous and ongoing FD activities. The FD has implemented a range of social forestry initiatives over the past 30 years. Also, during 2003-2008 the USAID funded Nishorgo project piloted FD-community forest management in five protected areas (Mitchell 2004). The establishment of a co-

management framework specific to the Sundarbans would facilitate the development of conservation activities, including alternative livelihood options and solutions to deal with THC. There may also be opportunities to involve other GoB bodies in initiatives for tiger conservation.

Furthermore, conserving the Sundarbans tiger population will require the creation of a transboundary approach with neighbouring India. There have been previous meetings and joint initiatives, but a more sustained effort is needed to formulate an overall strategy, and facilitate coordination of activities such as research and anti-poaching. Bangladesh can also open dialogues with other countries to help combat the illegal trade in tiger parts.

### **Box 3. Collaboration for conservation: Examples from other countries**

The Department of Wildlife and National Parks Peninsular Malaysia (DWNP) established the **Malaysian Conservation Alliance for Tigers (MYCAT)** in 2003. The aim of MYCAT is to facilitate and coordinate tiger conservation activities of partner organisations. The DWNP provides MYCAT with institutional support, and funds are acquired through donor grants (Yatim and Kawanishi 2003).

The Department of Environment and Forest in Assam set up a **Wildlife Areas Development and Welfare Trust** in 1996. The trust is authorised by the forest department to partner with nongovernmental organisations to help develop, fund, and implement conservation activities. The trust is proving so successful that other states in India are taking up the same approach (Wildlife Areas Development and Welfare Trust 2006).



**Crab fishermen in the Sundarbans**

# PART C

# Action Plan



## 1. OVERVIEW

This section contains the action plan for tiger conservation in Bangladesh over the next eight years. The eight year term for the BTAP was chosen as a sufficient length of time to mobilise a full scale conservation programme and realize achievement of objectives. The plan provides a vision for the future of tigers in Bangladesh and a set of goals to guide all conservation efforts. For each goal there are a set of objectives and a range of strategic actions to combat threats and challenges. As a strategic-level document, the BTAP does not contain a detailed implementation plan including activities, responsibilities, and budgets. Subsequent planning and mobilisation sessions will take the contents of the BTAP, turn these into project concepts, and develop the necessary collaboration needed to ensure their implementation.

## 2. VISION AND GOALS

### Vision

Protected tiger landscapes in Bangladesh, where wild tigers thrive at optimum carrying capacities\* and which continue to provide essential ecological services to mankind

### Goals

#### Goals to address threats

- Increase or stabilise the Sundarbans tiger population
- Maintain sufficient prey base to support the Sundarbans tiger population
- Maintain sufficient habitat to support the Sundarbans tiger and prey populations
- Assess the viability of tiger populations in the Chittagong Hill Tracts

#### Goals to address challenges

- Improve conservation capacity in the FD and mainstream tiger conservation into the GoB's development agenda
- Improve law enforcement to ensure protection of tiger, prey, and habitat
- Build capacity to implement awareness and education programmes
- Build capacity to conduct tiger conservation research and monitoring
- Encourage collaboration to support the FD in the implementation of the BTAP



**Brown-winged kingfisher (*Pelargopsis amauroptera*)**

*\*Carrying capacity* is defined as the maximum population size that the environment can sustain over the long-term, considering the available resources. Currently there is insufficient information to determine the optimum carrying capacity of tigers in the Sundarbans, and therefore no way to know if we are currently at, near, or below that level. Furthermore, when determining the desired future states of tiger, prey, and habitat, it must be taken into account that the Sundarbans supports both tiger and human needs. Therefore, perhaps the most pressing question to be answered is: What levels of human use can the Sundarbans sustain, without imperilling the tiger population and the essential ecological services the area provides?

### 3. OBJECTIVES AND STRATEGIC ACTIONS

This section outlines a set of objectives and strategic actions to achieve the threats and challenges goals based on the information presented in Part B. The current lack of information on threats and the current and desired states of tiger, prey, and habitat make it difficult to develop SMART (specific, measurable, achievable, realistic, and time bound) objectives to address the threats. This will make it difficult to monitor and evaluate progress against these objectives. For example, the objective to 'reduce unsustainable resource use' is not yet SMART because 'sustainable' has not yet been defined, so it is unknown by how much resource use should be reduced, and over what time period. An increase in baseline information is therefore needed to improve definition of the threat objectives. Achievement of the challenge objectives is more straightforward because, in most cases, success can be measured by the completion of the strategic actions.



Honey collectors rowing together with the tide



Table 1. Threats objectives and strategic actions

Direct tiger loss	
GOAL: Increase or stabilise the Sundarbans tiger population	
Threat objective	Strategic action
Evaluate the current and desired state of occupancy, connectivity, and size of tiger population	Develop methods for assessing tiger occupancy, connectivity, and population size
	Define target state tiger occupancy, connectivity, and population size with respect to optimum carrying capacity
	Model trends in tiger occupancy, connectivity, and population size under various threat and management scenarios
	Monitor changes in occupancy, connectivity, and size of tiger population
Minimise prey poaching	Determine nature and scale of tiger poaching and trade in tiger parts
	Improve intelligence relating to tiger poaching incidents
	Improve effectiveness of law enforcement
	Ensure penalties are sufficient to deter poachers, consumers, and traders
	Raise awareness in target groups about legal protection and importance of tigers and their prey
	Improve prosecution rate of poaching, consumption, and trade in tiger parts
	Understand and reduce domestic socio-economic dependencies on tiger poaching
	Develop measures to contribute to the battle against the international trade in tiger parts
	Monitor levels of tiger poaching, consumption, and trade in Bangladesh
Minimise tiger-human conflict	Determine scale, nature, and causes of tiger, human, and livestock killing
	Develop THC mitigation activities and supporting protocol to reduce tiger, human, and livestock killings
	Monitor numbers of human, livestock, and tiger killings

Threat objective	Strategic action
Assess other potential threats	Complete risk assessment and prioritise mitigation activities for tiger disease
<b>GOAL: Assess the viability of tiger populations in the Chittagong Hill Tracts</b>	
Assess the viability of tiger populations in the Chittagong Hill Tracts	Carry out occupancy and abundance survey of tiger and prey

<b>Prey depletion</b>	
<b>GOAL: Maintain sufficient prey base to support the Sundarbans tiger population</b>	
Threat objective	Strategic action
Evaluate the current and desired state of occupancy, connectivity, and size of prey population	Develop methods for assessing prey occupancy, connectivity, and population size
	Define target state prey occupancy, connectivity, and population size with respect to optimum carrying capacity
	Model trends in prey occupancy, connectivity, and population size under various threat and management scenarios
	Monitor changes in occupancy, connectivity, and size of prey population
Minimise prey poaching	Determine nature and scale of prey poaching and trade in prey parts
	Improve intelligence relating to prey poaching incidents
	Improve effectiveness of law enforcement
	Ensure penalties are sufficient to deter poachers, consumers, and traders
	Raise awareness in target groups about legal protection and importance of tigers and their prey
	Improve prosecution rate of poaching, consumption, and trade in prey parts
	Understand and reduce socio-economic dependencies on prey poaching
	Monitor levels of prey poaching, consumption, and trade in Bangladesh
Minimise tiger-human conflict	Complete risk assessment and prioritise mitigation activities for prey disease

Habitat loss and degradation	
GOAL: Maintain sufficient habitat to support the Sundarbans tiger and prey populations	
Threat objective	Strategic action
Evaluate current and desired state of tiger and prey habitats	Investigate tiger and prey habitat requirements (area, cover, and composition)
	Monitor change in area, cover, and composition of tiger and prey habitat
Reduce unsustainable forest resource use	Determine nature and scale of unsustainable resource use
	Understand socio-economic dependencies of forest users on the Sundarbans and develop alternative income opportunities
	Improve effectiveness of law enforcement in the forest
	Improve prosecution rate of illegal activities
	Monitor human impact on forest resources and level of illegal activities
Mitigate affects of changes in freshwater flow, siltation rates, salinity changes, and sea level	Assess changes in freshwater flow, siltation rates, salinity changes, and sea-level to prioritise management response
	Develop and implement adaptation strategies (in line with the Bangladesh Climate Change Strategy and Action Plan 2008 (MoEF 2008))
Assess other potential threats	Complete risk assessment and prioritise mitigation activities for pollution, invasive species, and future mineral and gas exploration/extraction



Fisherwomen arranging their nets to collect shrimp fry



Table 2. Challenges objectives and strategic actions

Institutional development and policy	
GOAL: Improve conservation capacity in the FD and mainstream tiger conservation into the GoB's development agenda	
Challenge objective	Strategic action
Build management capacity to plan, implement, and monitor BTAP activities	Assign dedicated FD WNCC staff to direct BTAP implementation and coordinate collaboration efforts
	Prioritise BTAP threats and challenges to develop implementation strategies with collaboration and budget requirements
	Develop a monitoring and adaptive management processes
	Develop a management and stakeholder reporting process
Build field-level capacity to deal with immediate tiger conservation needs	Develop a THC protocol to improve management decision-making for different conflict scenarios
	Develop THC alleviation strategies including: - Village Tiger Response Teams to reduce tiger and livestock killing - Forest Tiger Response Teams to reduce human killing incidents - Specialist teams to deal with situations requiring tiger capture
	Establish a wildlife crime unit to tackle tiger and prey poaching
	Establish a research team to undertake tiger, prey, and habitat monitoring programmes
Build capacity for long term tiger conservation to last beyond the eight years of the BTAP	Enrol selected FD officers for further study in conservation related-disciplines and leadership training
	Develop a sustainable financing mechanism for tiger conservation
	Conduct an organisational review to understand opportunities for retention of wildlife staff within WNCC and also for FD staff within the Sundarbans
	Develop and institutionalise a wildlife conservation training programme for wildlife and forestry staff
	Link Sundarbans staff reviews and promotions to tiger conservation goals and objectives
	Assess options for building capacity to manage and conserve fisheries in the Sundarbans

Threat objective	Strategic action
Incorporate tiger conservation into development plans	Develop an approach to integrate tiger and biodiversity conservation into wider development policy and action
	Complete an economic assessment of the benefits of Sundarbans ecosystem services
	Develop a monitoring and adaptive management processes
	Develop revenue generation approaches based on conservation friendly activities
Build field-level capacity to deal with immediate tiger conservation needs	Raise awareness in high and mid-level officials of other Government ministries about tiger and Sundarbans conservation and its relationship to development policy
	Raise public awareness across the country by mainstreaming tiger and Sundarbans conservation issues into the media

Forest protection and law enforcement	
GOAL: Improve law enforcement to ensure protection of tiger, prey, and habitat	
Challenge objective	Strategic action
Improve law enforcement capacity in the Sundarbans	Develop and implement a forest protection strategy to improve FD patrolling, monitoring, staffing, work incentives, and staff living conditions
	Train FD staff in legislation and their role in its enforcement
Strengthen effectiveness of legislation	Assess current tiger conservation related legislation, penalties, prosecution rate, and perceived risk of being punished
	Review adherence to related international conventions and treaties
Build field-level capacity to deal with immediate tiger conservation needs	Review current zonation of Sundarbans in relation to human use and tiger/prey abundance

Education and awareness	
GOAL: Build national capacity to implement awareness and education programmes	
Challenge objective	Strategic action
Ensure awareness and education is targeted at priority audiences	Develop a national tiger conservation education and awareness strategy
Build capacity to implement awareness and education programmes	Organise training to build national skills in conservation communication and social marketing

Research and monitoring	
GOAL: Increase capacity to conduct tiger conservation research and monitoring	
Challenge objective	Strategic action
Improve law enforcement capacity in the Sundarbans	Develop a prioritised tiger conservation research and monitoring agenda to guide government agencies, academic institutions, NGOs, and individual researchers
Improve tiger conservation knowledge base, and research and learning facilities	Establish a centre and network for tiger conservation and Sundarbans research and knowledge management
	Develop a platform to facilitate sharing of information between national and international tiger conservation researchers
	Establish a research station close to the forest to facilitate Sundarbans field work
	Assess existing national and regional courses to understand need for an in-country conservation biology training programme
Build new generation of tiger conservation scientists	Set up tiger conservation scholarships to support study in a range of disciplines to tackle priority research and monitoring items

Collaboration	
GOAL: Encourage collaboration to support the FD in the implementation of the BTAP	
Challenge objective	Strategic action
Facilitate the engagement and coordination of collaborators	Develop a platform to build collaboration between the FD and other parties for technical and funding support for BTAP activities
Increase collaboration to increase available technical skills	Complete gap assessment of conservation skills to determine national and international collaboration requirements
	Engage relevant collaborators to help FD achieve BTAP objectives
	Facilitate training and skills sharing between collaborators to increase national capacity for tiger conservation



Challenge objective	Strategic action
Work with local communities to build joint solutions for tiger conservation	Develop a community collaboration approach for forest and tiger conservation including a supporting institutional structure
	Develop capacity of local community members in mangrove forest and tiger conservation, participatory planning, and development of alternative livelihoods
Engage other government bodies to increase BTAP implementation capacity	Undertake joint initiatives with other Government agencies in areas of common interest, e.g. incorporation of Sundarbans conservation material into educational initiatives arranged by the Ministry of Education
Engage neighbouring countries to implement transboundary conservation initiatives	Raise awareness in high and mid-level officials of other Government agencies in tiger and Sundarbans conservation issues
	Open communication channels to develop joint activities with government and non-government organisations in neighbouring countries
	Develop a platform to enable government collaboration on cross-border monitoring and control of illegal trade in tiger parts
	Develop links and networks for sharing research results and conducting collaborative transboundary research
Collaborate with the international community to tackle the trade in tiger parts	Form relationships with other governments to conduct joint initiatives aimed at reducing the international trade in tiger parts



**A fishing trawler stranded at low tide**

#### 4. PRIORITISATION

To focus conservation efforts, the threats need to be prioritised in terms of their potential impact, and the current and desired states of tiger, prey, and habitat (TNC 2003; WWF 2007). This exercise will be carried out in the first year of BTAP implementation. In the meantime, tiger conservation activities will continue using informal judgement of threat priorities based on existing knowledge.

A second process will be carried out to prioritise strategic actions under each objective. A balance must be struck between resources spent on more research versus the need for immediate mitigation activities (Lee 1999; Wilhere 2002). Actions can be ranked based on criteria such as their potential benefit, cost, feasibility, and leverage (TNC 2003). This threat prioritisation and activity selection process will result in the formation of an overall eight year implementation plan containing milestones and strategic actions grouped into project concepts. Collaboration will be needed for both in the development of this prioritisation process and the subsequent implementation plan.

#### 5. MONITORING AND EVALUATION

Monitoring and evaluation of progress against the BTAP goals will provide a way of measuring the success of the tiger conservation efforts, and enable the adaptation of conservation activities based on lessons learnt, new information, and changing conditions. Monitoring of tiger, prey, and habitat levels will be carried out every two years to assess the

achievement of progress against the threat goals (Box 4). Likewise, a two yearly monitoring approach will be devised to evaluate progress against the challenges goals. A process will also be developed for the evaluation of progress of strategic actions and achievement of their associated objectives. At the end of its eight year term, the BTAP will be updated for its next term, in light of completed activities and changing conditions.

#### 6. HOW TO GET INVOLVED

The FD welcomes collaboration at all levels to support implementation of the BTAP. Those interested in becoming involved can get in touch with the FD who can provide further information on current tiger conservation work in Bangladesh and opportunities for collaboration.



**Honey collection teams racing into the forest at the start of honey collecting season**



**Tourists coming ashore at Katka jetty in the East Wildlife Sanctuary**

#### Box 4. Monitoring changes in tigers, prey, and habitat

It is notoriously difficult to count tigers, but if we are to monitor changes in their population and evaluate the effectiveness of our conservation activities, then we must find a way to overcome this challenge. There have been a number of unsuccessful attempts to count absolute numbers of Sundarbans tigers based on short field visits, interviews with forest workers, and the Indian pugmark method (Seidensticker 1987; Tamang 1993; Jalil 1998; Bangladesh Forest Department 2004). The Indian pugmark method is based on identifying individual tigers from their pugmarks, but this is no longer considered scientifically sound by authorities in India and international scientists (Karanth *et al.* 2003; Project Tiger 2005). Camera trapping has become a popular way of estimating tiger abundance, but the sheer size of the Sundarbans and the lack of identifiable tiger travel routes make this technique impractical for tracking changes in the whole population. However, camera trapping has been carried out to investigate tiger and prey density at some sites (Khan Unpubl. data).



**Tiger tracks in the mud**

A **tiger monitoring** system has recently been developed to measure changes in *relative* tiger abundance (rather than *absolute* numbers) over the entire Bangladesh Sundarbans. This survey works by counting the number of tiger tracks along *khal* (canal) banks in a systematic way across the forest. It is based on the assumption that in areas with more tracks, there are more tigers. If track numbers decrease in an area of the forest, then it will be assumed that tiger numbers have fallen, and management



**Searching for tiger tracks along khal banks**

action will be taken. It does not try to identify unique tigers from their tracks, rather it counts the total number of tiger tracks per kilometre of *khal* to produce a map showing the densities of tiger tracks across the whole forest. The first survey was completed in 2007 (Fig. 2), with the aim of repeating the survey every two years (Barlow *et al.* 2008). Likewise, monitoring systems need to be developed to track the changes in the prey population and also in habitat cover and composition. A system of **prey monitoring** using pellet counts to determine absolute abundance is currently under development for this purpose (Ahmed *et al.* Unpubl. data). With regards to habitat monitoring, previous studies to assess habitat change were based on one-off forest inventories devised using different methodologies, which made comparisons to work out change over time problematic (Iftekhar and Saenger 2007). Therefore, a standardised long-term **habitat monitoring** programme needs to be developed.



## LITERATURE CITED

- Agrawala, S., T. Ota, A. U. Ahmed, J. Smith, and M. van Aalst. 2003. Development and Climate Change in Bangladesh: Focus on Coastal Flooding and the Sundarbans. Environment Directorate and Development Cooperation Directorate, Organisation for Economic Cooperation and Development (OECD), Paris, France.
- Ale, S. B. and C. J. Whelan. 2008. Reappraisal of the role of big, fierce predators. *Biodiversity Conservation*, 17: 685- 690.
- Allison, M. A., S. R. Khan, S. L. Goodbred Jr, and S. A. Kuehl. 2003. Stratigraphic evolution of the late Holocene Ganges-Brahmaputra. *Sedimentary Geology* 155:37-342.
- Appel, M. J. G. and B. A. Summers. 1995. Pathogenicity of morbilliviruses for terrestrial carnivores. *Veterinary Microbiology* 44:187-191.
- Bangladesh Forest Department. 2004. Final tiger census report. Government of Bangladesh.
- Barlow, A. C. D. 2009. The Sundarbans tiger: Adaptation, population status, and conflict management. PhD Thesis, University of Minnesota.
- Barlow, A. C. D., M. I. U. Ahmed, M. M. Rahman., A. Howlader, A. C. Smith, and J. L. D. Smith, 2008. Linking monitoring and intervention for improved management of tigers in the Sundarbans of Bangladesh *Biological Conservation*, 141:2031-2040.
- Biswas, H., J. K. Choudhury, A. Nishat, and M. M. Rahman. 2007. Do invasive plants threaten the Sundarbans mangrove forest of Bangladesh? *Forest Ecology and Management* 245:1-9.
- Biswas, S. R., A. U. Mallick, J. K. Choudhury, and A. Nishat. 2008. A unified framework for the restoration of Southeast Asian mangroves-bridging ecology, society and economics. *Wetlands Ecology and Management* DOI 10.1007/s11273-008-9113-7.
- Blower, J. 1985. Sundarbans Forest Inventory Project, Bangladesh. Wildlife conservation in the Sundarbans. Project Report 151.
- Carroll, C., and D. G. Miquelle. 2006. Spatial viability analysis of Amur tiger *Panthera tigris altaica* in the Russian Far East: the role of protected areas and landscape matrix in population persistence. *Journal of Applied Ecology* 43:1056-1068
- Chapron, G., D. G. Miquelle, A. Lambert, J. M. Goodrich, S. Legrandre, and J. Clobert. 2008. The impact on tigers of poaching versus prey depletion. *Journal of Applied Ecology*, 45:1667-1674.
- Chaudhuri, A. B., A. Choudhury, M. Z. Hussain, and G. Acharya. 1994. Mangroves of the Sundarbans. IUCN.
- Canonizado, J. A. and M. A. Hossain. 1998. Integrated forest management plan for the Sundarbans Reserved Forest. Bangladesh Forest Department.
- Curtis, S. J. 1933. Working plans for the forests of the Sundarbans Division for the period from 1st April 1931 to 31st March 1951, Vol. 1. Calcutta, India, Bengal Government Press.
- Dinerstein, E., C. Loucks, E. Wikramanayake, J. Ginsberg, E. Sanderson, J. Seidensticker, J. Forrest, G. Bryja, A. Heydlauff, S. Klenzendorf, P. Leimgruber, J. Mills, T. G. O'Brien, M. Shrestha, R. Simons, and M. Songer. 2007. The fate of wild tigers. *BioScience* 57:508-514.
- Goodrich, J. M., K. S. Quigley, D. G. Miquelle, E. N. Smirnov, L. L. Kerley, H. B. Quigley, M. G. Hornocker, and D. Armstrong. 2005. Blood chemistry and infectious diseases of Amur tigers. In Miquelle, D. G., E. N. Smirnov, and J. M. Goodrich (Eds.). *Tigers of Sikhote-Alin Zapovednik: ecology and conservation*. PSP, Vladivostok, Russia. 224 pp. (in Russian), pp 43-49
- Goodrich, J. M., L. L. Kerley, E. N. Smirnov, D. G. Miquelle, L. McDonald, H. B. Quigley, M. G. Hornocker, and T. McDonald. 2008. Survival rates and causes of mortality of Amur tigers on and near the Sikhote-Alin Biosphere Zapovednik. *Journal of Zoology*, 276:323-329.
- Greenwood, C. J. 2009. Wildlife Trust of Bangladesh and Sundarbans Tiger Project Overview 2009. WTB Report.
- Hansen, J. E. 2007. Scientific reticence and sea level rise. *Environmental Research Letters* 2.
- Hendry, M. D. and G. Digerfeldt. 1989. Paleogeography and palaeoenvironments of a tropical coastal wetland and adjacent shelf during Holocene submergence, Jamaica. *Paleogeography, Paleoclimatology, Palaeoecology*, 73:1-10.

- Hendrichs, H. 1975. The status of the tiger *Panthera tigris* in the Sundarbans mangrove forest (Bay of Bengal). *Saugetierk. Mitt.* 23:161-199
- Hesselink, F., W., Goldstein, P. van Kempen, T. Garnett, and J. Dela. 2007. Communication, Education and Public Awareness (CEPA): A toolkit for National Focal Points and NBSAP coordinators. Secretariat of the Convention on Biological Diversity and IUCN: Montreal, Canada.
- Hussain, Z. and G. Acharya (Eds.). 1994. Mangroves of the Sundarbans, vol. II: Bangladesh. IUCN, Bangkok. Iftekhar, M. S., and M. R. Islam. 2004. Degeneration of Bangladesh's Sundarbans mangroves. *The international forestry review*, 6:123-135.
- Iftekhar, M. S. and P. Saenger. 2008. Vegetation dynamics in the Bangladesh Sundarbans mangroves: a review of forest inventories. *Wetlands Ecological Management*, 16: 291-312.
- Inman, M. 2009. Where warming hits hard. *Nature* 3:18-21. Islam, T. and R. E. Peterson. 2008. Climatology of landfalling tropical cyclones in Bangladesh 1877-2003. *Natural Hazards*, 45:115-135.
- IUCN. 2004. Draft National Biodiversity Strategy and Action Plan. IUCN, Bangladesh country office. IUCN. 2008. The 2008 Review of the IUCN Red List of Threatened Species. IUCN
- Jalil, S. M. 1998. Bengal tiger in Bangladesh. Report presented at the Year of the Tiger Conference, Dallas.
- Jagrata Juba Shangha. 2003. Human-wildlife interactions in relation to the Sundarbans reserved forest of Bangladesh. Sundarbans Biodiversity Project report.
- Karanth, U. K., J. D. Nichols, J. Seidensticker, E. Dinerstein, J. L. D. Smith, C. McDougal, A. J. T. Johnsingh, R. S. Chundawat, and V. Thapar. 2003. Science deficiency in conservation practice: the monitoring of tiger populations in India. *Animal Conservation* 6:141-146.
- Karanth, K. U., N. S. Kumar, J. D. Nichols, W. A. Link, and J. E. Hines. 2004. Tigers and their prey: Predicting carnivore densities from prey abundance. *Proceedings of the National Academy of Sciences of the United States of America*, 101:4854-4858
- Karanth, K. U., J. D. Nichols, N. S. Kumar, and J. E. Hines. 2006. Assessing tiger population dynamics using photographic capture-recapture sampling. *Ecology*, 87:2925-2937.
- Keawcharoen, J., K. Oraveerakul, T. Kuiken, R. A. M. Fouchier, A. Amonsin, S. Payungporn, S. Noppornpanth, S. Wattanodorn, A. Theamboonlers, and R. Tantilertcharoen. 2004. Avian influenza H5N1 in tigers and leopards. *Emerging Infectious Disease*, 10:2189-2191.
- Kenny, J. S., J. L. D. Smith, A. M. Starfield, and C. W. McDougal. 1995. The long-term effects of tiger poaching on population viability. *Conservation Biology*, 9:1127-1133
- Khan, M. A. R. 1986. The status and distribution of the cats in Bangladesh. *Cats of the world*. National Wildlife Federation, USA. pp 43-49.
- Khan, M.A.R. 1987. The problem tiger of Bangladesh. In (R. L. Tilson and Seal, U.S. Eds.). *Tigers of the World*. New Jersey, U.S.A.: Noyes Publications. pp 92-96.
- Khan, M. M. H. 2004. Ecology and conservation of the Bengal tiger in the Sundarbans mangrove forest of Bangladesh. PhD Thesis, University of Cambridge.
- Khan, M. M. H., and D. J. Chivers. 2007. Habitat preferences of tigers *Panthera tigris* in the Sundarbans East Wildlife Sanctuary, Bangladesh, and management recommendations. *Oryx*, 41:463-468.
- Lee, K. N. 1999. Appraising adaptive management. *Conservation Ecology*, 3:3. Ministry of Environment and Forests. 2007. Bangladesh Capacity Development Action Plan for Sustainable Environmental Governance. Ministry of Environment and Forests, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh. xxii + pp 252.
- Ministry of Environment and Forests. 2008. Bangladesh Climate Change Strategy and Action Plan 2008. Ministry of Environment and Forests, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh. xvi + pp 68
- Mitchell, A. H., M. K. Alam, and A. Bari, 2004. Assessment of the Forest Department's institutional organization and capacity to manage the protected area system of Bangladesh. Nishorgo Support Project Report.
- Mitra, S. N. 1957. Banglar shikar prani [Animals for hunting in Bengal]. Government of West Bengal, Calcutta. pp 139 (in Bengali).

- Myers, D. L., A. Zurbriggen, H. Lutz, and A. Pospischil. 1997. Distemper: not a new disease in lions and tigers. *Clinical and Vaccine Immunology*, 4:180.
- Nowell, K. 2000. Far from a Cure: The Tiger Trade Revisited. TRAFFIC International. Nowell, K. and L. Xu. 2007. Taming the Tiger Trade: China's Markets for Wild and Captive Tiger Products Since the 1993 Domestic Trade Ban, 64 pp. A TRAFFIC East Asia monograph, ISBN:978-971.
- Pfeffer, W.T., J. T. Harper, and S. O'Neel. 2008. Kinematic Constraints on Glacier Contributions to 21st-Century Sea-Level Rise. *Science*, 321:1340-1343.
- Project Tiger. 2005. The Report of the Tiger Task Force: Joining the Dots. Government of India. Olmsted, R. A., R. Langley, M. E. Roelke, R. M. Goeken, D. Adger-Johnson, J. P. Goff, J. P. Albert, C. Packer, M. K. Laursen, and T. M. Caro. 1992. Worldwide prevalence of lentivirus infection in wild feline species: epidemiologic and phylogenetic aspects. *Journal of Virology*, 66:6008.
- Rahmstorf, S. 2007. A semi-empirical approach to projecting future sea-level rise. *Science*, 315:368-370.
- Reza, A. H. M. A., M. M. Feeroz, and M. A. Islam. 2001a. Food habits of the Bengal tiger (*Panthera tigris tigris*) in the Sundarbans. *Bangladesh Journal of Zoology*, 29:173-179.
- Reza, A. H. M. A., M. M. Feeroz, and M. A. Islam. 2001b. Habitat preference of the Bengal tiger, *Panthera tigris tigris* in the Sundarbans of Bangladesh. *Bangladesh Journal of Life Science*, 13:215-217.
- Reza, A. H. M. A., M. M. Feeroz, and M. A. Islam. 2002a. Man-tiger interaction in the Bangladesh Sundarbans. *Bangladesh Journal of Life Science*. 14:75-82.
- Reza, A. H. M. A., M. M. Feeroz, and M. A. Islam. 2002b. Prey species density of the Bengal tiger in the Sundarbans. *Journal of Asiatic Society Bangladesh, Science*, 28: 35-42.
- Reza, A. H. M. A., M. A. Islam, M. M. Feeroz, and A. Nishat. 2004. Bengal tiger in the Bangladesh Sundarbans. IUCN The World Conservation Union, Bangladesh Country Office, Dhaka, Bangladesh pp141.
- Sanderson, E, J. Forrest, C. Loucks, J. Ginsberg, E. Dinerstein, J. Seidensticker, P. Leimgruber, M. Songer, A. Heydlauff, T. O'Brien, G. Bryja, S. Klenzendorf, and E. Wikramanayake. 2006. Setting Priorities for the Conservation and Recovery of Wild Tigers: 2005–2015. The Technical Assessment. Washington (DC): WCS, WWF, Smithsonian, NFWF-STF.
- Seidensticker, J. 1987. Managing tigers in the Sundarbans: Experience and opportunity. In (R. L. Tilson, and U. S. Seal, Eds.). *Tigers of the world: the biology, biopolitics, management, and conservation of an endangered species*. Noyes Publications, Park Ridge, New Jersey, pp 416–426.
- Seidensticker, J. and M. A. Hai. 1983. The Sundarbans wildlife management plan: conservation in the Bangladesh coastal zone. Forest Department, Government of the People's Republic of Bangladesh, Dhaka, and WWF, Gland 129.
- Smith, J. L. D. and C. W. McDougal. 1991. The contribution of variance in lifetime reproduction to effective population size in tigers. *Conservation Biology*, 5: 484-490.
- Smith, J. L. D., C. W. McDougal and M. E. Sunquist, 1987. Land tenure system in female tigers in R. L. Tilson. and U. S. Seal, editors. *Tigers of the world: biology, biopolitics, management and conservation of an endangered species*. Noyes Publications, New Jersey.
- Stanley, D. J. and A. K. Hait. 2000. Holocene depositional patterns, neotectonics and Sundarban mangroves in the Western Ganges-Bramaputra delta. *Journal of Coastal Research*, 16:26-39.
- The Nature Conservancy. 2003. The Five-S Framework for site conservation: A practitioner's handbook for site conservation planning and measuring conservation success. Arlington, Virginia.
- Tamang, K. M. 1993. Wildlife management plan for the Sundarbans reserved forest. Integrated Resource Development of the Sundarbans Reserved Forest, Bangladesh, vol. 1, UNDP/FAO project no. BGD/84/056. pp113
- Wegge, P., O. Morten, C. P. Pokharel, and T. Storaas. 2009. Predator-prey relationships and the responses of ungulates and their predators to the establishment of protected areas: A case study of tigers, leopards and their prey in Bardia National Park, Nepal. *Biological Conservation*, 142: 189-202.
- Wildlife Areas Development and Welfare Trust. 2006. Strengthening and capacity building of the Wildlife Areas Development and Welfare Trust. Final report.



- Wilhere, G. F. 2002. Adaptive Management in Habitat Conservation Plans. *Conservation Biology*, 16:20-29. World Wildlife Fund. 2007. WWF standards of conservation project and program management.
- Yatim, S. H. and K. Kawanishi. 2003. Malaysian Conservation Alliance for Tigers (MYCAT): Malaysian government takes leadership in fostering conservation partnership for tigers and their habitats. *Cat News*, 39: 23-24.



UNIVERSITY  
OF MINNESOTA